CANMET

REPORT 83-3E

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

CERTIFIED REFERENCE MATERIALS

H.F. STEGER

APRIL 1983

MINERALS RESEARCH PROGRAM
MINERAL SCIENCES LABORATORIES

41 pp

Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

Canada

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Available in Canada through

Authorized Bookstore Agents
and other bookstores

or by mail from

Canadian Government Publishing Centre
Supply and Services Canada
Hull, Quebec, Canada K1A 0S9

CANMET
Energy, Mines and Resources Canada,
555 Booth St.,
Ottawa, Canada K1A 0G1

or through your bookseller

Catalogue No. M38-13/83-3E
ISBN 0-660-11338-4

Canada: $5.25
Other countries: $6.30

Price subject to change without notice.

CERTIFIED REFERENCE MATERIALS

Compiled by

H.F. Steger*

PREFACE

The Canadian Certified Materials Project (CCRMP) is a facet of the Minerals Technology Activity of CANMET's Minerals and Earth Sciences Research Program.

Emphasis in CCRMP is on the preparation of compositional reference materials for use in analytical laboratories associated with mining, metallurgy and the earth sciences. Such materials include ores or host rock, mineral concentrates and waste products such as a blast furnace slag and an electrostatic-precipitator collected dust. The certified constituents and their levels of concentration in these compositional reference materials are summarized in the index as a convenience to potential users for selecting the reference material most suitable for the intended purpose.

Other certified reference materials avaiable are a set of three commercial-grade purity, copper alloys, a set of three phosphor bronzes, two syenite and one gabbro rock, and a suite of four soils.

This catalogue describes the certified and provisional reference materials that may be purchased from CANMET through the Coordinator of CCRMP. Where possible, the source, mineralogical and chemical composition and recommended values of the certified constituents are stated. Contrary to the format of previous catalogues, the Price List and the procedure for the purchase of reference materials are now published separately.

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Pour obtenir la version française de ce catalogue, prière de s'adresser au coordonnateur du CCRMP.

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CERTIFIED REFERENCE MATERIALS

ORES AND RELATED MATERIALS

CAVEAT PERTAINING TO SULPHIDE-BEARING ORES

Finely ground sulphide-bearing ores are susceptible to oxidation on long or repeated exposure to air. All bottles of such reference materials have therefore been sealed under nitrogen in laminated foil pouches to provide long-term protection against oxidation at CANMET. The stability of these pouched materials is being monitored on a regular basis.

The assigned values for the certified constituents pertain to the date when issued and CCRMP is not responsible for changes occurring after receipt by the user. It is strongly recommended that unsealed bottles be stored under an inert gas in a dessicator or in a new heat-sealed foil pouch. Moreover, the contents of the bottles should be exposed to air for the shortest time possible.

Antimony Ore CD-1

CD-1 was prepared in 1975 from ore of the Lake George mine of Consolidated Durham Mines and Resources Limited at Prince William, New Brunswick. It contains significant concentrations of antimony and arsenic, and thus should be especially useful in assessing methods in which there is potential interference between these elements. The following minerals are present in approximate decreasing order of abundance: quartz, mica, clay minerals, stibnite, pyrite, arsenopyrite, pyrrhotite, and traces of chalcopyrite and chalcostibnite. The approximate chemical composition of CD-1 is given in the following table.

Approximate chemical composition

Constituent	wt %
Si	32.9
Al	5.5
Sb	3.57
S	3.1
Fe	2.8
K	1.8
Ca	1.4
As	0.66
Mg	0.6
C (total)	0.2
Na	0.1
Pb	0.02
Cu	<0.01
H_2O (105°C)	0.2
L.O.I. (950°C)	4.0

Twenty laboratories provided analytical results for either antimony or arsenic or both.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Sb	3.57 ± 0.04
As	0.66 ± 0.02

A copy of CANMET Report 77-63 "Antimony-arsenic ore CD-1 - A certified reference material" will be provided with each order of CD-1.

Blast Furnace Slag SL-1

SL-1 was prepared in 1975 from material donated by the Steel Company of Canada Ltd. at Hamilton, Ontario for use in analytical laboratories associated with the iron and steel industry.

Although the interlaboratory program which involved 21 laboratories yielded results for 13 constituents, only six met the criteria for certification; values for the others are provisional.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
SiO_2	35.73 ± 0.13
CaO	37.48 ± 0.18
MgO	12.27 ± 0.15
Al_2O_3	9.63 ± 0.09
Total Fe as FeO	0.92 ± 0.04
S	1.26 ± 0.03

Provisional values

Constituent	wt %
TiO_2	0.38
MnO	0.86
Na_2O	0.39
K_2O	0.51

A copy of CANMET Report 77-57 "Blast furnace slag SL-1: Its preparation for use as a certified reference material" will be provided with each order of SL-1.

Copper Concentrate CCU-1

CCU-1 was prepared from a sample of a flotation concentrate from the Ruttan mine of Sherritt Gordon Mines Limited, at Lynn Lake, Manitoba. It contains a number of minor and trace elements at analytically useful levels of concentration.

Mineralogical composition

Mineral	wt %
Chalcopyrite	82
Pyrite	9
Sphalerite	9
Pyrrhotite	trace

Thirty-three laboratories provided analytical results for one or more of the constituents. Preliminary data for 10 other elements are also available.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Cu	24.71 ± 0.05
Zn	3.22 ± 0.03
SiO_2	2.61 ± 0.08
Al_2O_3	0.247 ± 0.007
Pb	0.106 ± 0.005
Ag	139 ± 3 µg/g
Hg	61 ± 2 µg/g
Au	7.5 ± 0.2 µg/g

A certificate of analysis will be issued with each order of CCU-1. A copy of CANMET Report 79-16 "Copper concentrate CCU-1 - A certified reference material" will be forwarded free of charge, on request, to the Coordinator, CCRMP.

Copper-Molybdenum Ore HV-1

HV-1 is a mixture of materials taken from large, low-grade copper-molybdenum porphyry deposits in the Highland Valley area of British Columbia; it is intended to be representative of samples analyzed in large numbers by enterprises associated with the exploitation of these deposits.

Mineralogical composition

Mineral	wt %
Quartz	40.7
Plagioclase	26.9
Sericite	12.3
Orthoclase	10.6
Biotite	2.3
Amphibole and pyroxene	2.0
Calcite	1.5
Clay minerals	1.0
Bornite	0.6
Hematite and magnetite	0.6
Tramp iron	0.4
Chalcopyrite	0.3
Rutile	0.3
Pyrite	0.1
Molybdenite	0.1
Barite	0.1
Zircon	trace

Approximate chemical composition

Constituent	wt %
O	49.2
Si	33.9
Al	6.61
K	2.82
Na	2.26
Fe (total)	1.88
Ca	1.40
Cu	0.52
Mg	0.34
S	0.34
C (total)	0.20
Ti	0.16
Mo	0.058
Mn	0.03
L.O.I. (980°C)	1.42

Twenty-three laboratories provided analytical results for copper and molybdenum for certifying HV-1.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Cu	0.522 ± 0.005
Mo	0.058 ± 0.002

A copy of Mines Branch Technical Bulletin TB 167 "Copper-molybdenum ore HV-1: Its characterization and preparation for use as a standard reference material" will be provided with each order of HV-1.

Gold Ore MA-1

MA-1 was prepared from mill feed from Willroy Mines Limited, Macassa Division, Kirkland Lake, Ontario. It is a relatively simple siliceous ore containing elemental gold. Although CCRMP has also certified PTC-1 and PTM-1 for gold, these are rich in one or more of copper, nickel and iron, and contain platinum-group metals, thus being unsatisfactory for laboratories needing a simple gold ore as a reference material.

Approximate chemical composition

Constituent	wt %
O	45
Si	24.9
Al	5.7
Fe	5.3
Ca	4.4
K	4.2
C (total)	2.1
C (CO_2)	1.8
Na	1.5
S	1.5
H_2O (105°C)	0.1
L.O.I.	6.5

Twenty-four laboratories provided gold results by one or more of three methods.

RECOMMENDED VALUE AND 95% CONFIDENCE INTERVALS

Constituent	oz/ton	µg/g
Au	0.519 ± 0.005	17.8 ± 0.2

A copy of report MSL 75-29(TR) "Gold ore MA-1: Its preparation and characterization for use as a certified reference material" will be provided with each order of MA-1.

Gold Ore MA-2

MA-2 was prepared from waste rock from Willroy Mines Limited, Macassa Division, Kirkland Lake, Ontario. It is a relatively simple siliceous ore containing elemental gold. Silver is present at approximately one third the gold content. MA-2 is intended to serve as a reference material in the analysis of low-grade gold ores or related materials and therefore complements gold reference ore MA-1 for which gold is certified at 17.8 µg/g.

Constituent	wt %
SiO_2	51.3
Al	8.6
K	4.9
Fe	4.6
Ca	3.7
Na	2.6
C (Total)	1.6
S	0.054
L.O.I.	6.0
H_2O (105°C)	0.1

Twenty two laboratories provided analytical results for gold. A fire-assay procedure combined with either an atomic absorption or gravimetric finish was the most frequently employed method.

RECOMMENDED VALUE AND 95% CONFIDENCE INTERVALS

Constituent	oz/ton	µ/g
Au	0.0542 ± 0.0017	1.86 ± 0.06

A certificate of analysis will be issued with each order of MA-2. A copy of CANMET Report 81-13E "MA-2: A certified gold reference ore" will be forwarded free of charge on request to the Coordinator, CCRMP.

Iron Ore SCH-1

Reference ore SCH-1 was donated to CCRMP by the Iron Ore Company of Canada in 1973. It is from the Schefferville, Quebec area and is hematite with a mixture of unidentified hydrous oxides of iron, minor magnetite and trace pyrolusite. The gangue consists mainly of quartz with minor amounts of feldspar and traces of biotite, chlorite and amphibole.

Twenty-four laboratories provided analytical results for one or more of the selected elements in SCH-1.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Fe	60.73 ± 0.09
Si	3.78 ± 0.04
Al	0.509 ± 0.009
Ca	0.029 ± 0.003
Mg	0.020 ± 0.001
Na	0.019 ± 0.002
K	0.026 ± 0.002
Mn	0.777 ± 0.008
Ti	0.031 ± 0.002
S	0.007 ± 0.001
P	0.054 ± 0.003

A copy of report MSL 75-168(TR) "Iron ore SCH-1: Its characterization and preparation for use as a certified reference material" and CANMET Report 78-5 "Certification of reference iron ore SCH-1 for sodium and potasium" will be provided with each order.

Iron Ore MW-1

Reference ore MW-1 was donated to CCRMP in 1980 by the Quebec Cartier Mining Company. It is a concentrate of iron ore typical of Mount Wright, Quebec, and is essentially specular hematite containing minor to trace quartz, iron silicates and ilmenite.

Fifteen laboratories provided analytical results for one or more of the 12 selected elements in MW-1. However, only eight were ultimately certified.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %		
Fe (total)	66.08	±	0.06%
Fe (ferrous)	1.36	±	0.05%
SiO_2	4.60	±	0.07%
Al_2O_3	0.30	±	0.01%
CaO	0.053	±	0.004%
MgO	0.034	±	0.003%
P	0.011	±	0.001%
K	0.011	±	0.001%

Provisional values

Constituent	wt %
TiO_2	0.13
Mn	0.016
S	0.011
Na	0.011

A certificate of analysis will be issued with each order for MW-1. A copy of CANMET Report 82-16E "MW-1: A Certified Reference Iron Ore" will be supplied free of charge on request to the Coordinator, CCRMP.

Lead Concentrate CPB-1

CPB-1 was prepared from a sample of a flotation concentrate from the Sullivan mine of Cominco Ltd., at Kimberley, British Columbia. It is mineralogically complex with a relatively large number of minor and trace elements at analytically useful levels of concentration.

Mineralogical composition

Mineral	wt %
Galena	72.5
Pyrrhotite	12
Sphalerite	7
Pyrite	3
Iron oxides	1
Aluminosilicates	1
Carbonates	1
Chalcopyrite	0.5
Boulangerite	0.5

Twenty-five laboratories provided analytical results for one or more of the constituents. Preliminary data for eight other elements are also available.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Pb	64.74 ± 0.12
S	17.8 ± 0.2
Fe	8.43 ± 0.06
Zn	4.42 ± 0.04
SiO_2	0.74 ± 0.04
Sb	0.36 ± 0.03
Al_2O_3	0.28 ± 0.02
Cu	0.254 ± 0.004
As	0.056 ± 0.003
Bi	0.023 ± 0.002
Cd	0.0143 ± 0.0005
Ag	626 ± 6 µg/g
Hg	5.5 ± 0.5 µg/g

A certificate of analysis will be issued with each order for CPB-1. A copy of CANMET Report 79-15 "Lead concentrate CPB-1 - A certified reference material" will be forwarded free of charge on request to the Coordinator, CCRMP.

Molybdenum Ore PR-1

Molybdenum ore PR-1 was obtained from the Preissac Molybdenum mine near Cadillac, Quebec in 1970. It is from a vein-type deposit in a sericite granite.

Mineralogical composition

Mineral	wt %
Quartz	70.27
Feldspar	18.46
Calcite	2.37
Muscovite	2.30
Chlorite	1.29
Molybdenite	1.02
Fluorite	0.96
Pyrite	0.58
Bismuthinite	0.08
Garnet	0.07
Bismuth	0.06
Rutile	0.05
Galena	0.04
Sphalerite	0.03
Chalcopyrite	0.03

Approximate chemical composition

Constituent	wt %
O	49.2
Si	39.2
Al	2.39
K	1.95
Ca	1.44
Fe	1.24
C (total)	1.08
S	0.793
Mo	0.594
Na	0.54
F	0.47
Bi	0.111
Mg	0.09
Pb	0.04
Ti	0.03
Zn	0.02
Mn	0.02
Ni	0.01
Cu	0.01
H_2O	0.29

Nineteen laboratories participated in the program to certify PR-1 for molybdenum, bismuth, iron, and sulphur.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Mo	0.594 ± 0.016
Bi	0.111 ± 0.004
Fe	1.244 ± 0.019
S	0.793 ± 0.016

A copy of Mines Branch Technical Bulletin TB 139 "Molybdenum ore, PR-1: Its characterization and preparation for use as a standard reference material" will be provided with each order of PR-1.

Nickel-Copper-Cobalt SU-1a

SU-1a is intended as a replacement for reference ore SU-1, the supply of which has been exhausted. The material is typical of the Sudbury region and is a sample of feed to the Clarabelle mill of the International Nickel Company.

Mineralogical composition

Mineral	Weight %
Chlorite	27
Quartz	19
Feldspar	18
Mica	15
Amphibole	15
Calcite	1
Siderite	1
Sphalerite	2.0
Pyrrhotite	1.1
Pentlandite	0.8
Chalcopyrite	0.1

Approximate chemical composition

Constituent	wt %
SiO_2	38
Fe	20
S	10
Al	5
Ca	3.5
Mg	3.0
Ni	1.3
Cu	1.0
Co	0.04
Pb	0.01
Ag	5.6 ppm
Pd	0.6 ppm
Pt	0.5 ppm
Au	0.2 ppm

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Ni	1.233 ± 0.008
Cu	0.967 ± 0.005
Co	0.041 ± 0.001
Ag	4.3 ± 0.3 µg/g
Pt	0.41 ± 0.06 µg/g
Pd	0.37 ± 0.03 µg/g

Twenty-three laboratories provided results for one or more of nickel, copper, cobalt, platinum, palladium and silver. Preliminary data for gold and rhodium are also presented.

A certificate of analysis will be issued with each order of SU-1a. A copy of CANMET Report 80-9 "SU-1a: A certified nickel-copper-cobalt reference ore" will be forwarded on request to the Coordinator, CCRMP.

Nickel-Copper-Cobalt UM-1

UM-1 is an ultramafic rock from the Giant Mascot mine at Hope, British Columbia. It is one of a suite of three ultramafic rocks that have been termed geochemical standards for the determination of ascorbic acid/hydrogen peroxide-soluble nickel, copper, and cobalt. Because UM-1 contained ore-grade concentrations of nickel, copper, and cobalt it was chosen along with SU-1 as a suitable reference material for these elements.

Approximate chemical composition

Constituent	wt %
O	36.5
Mg	21.7
Si	17.6
Fe	13.4
S	3.53
Ca	1.67
Ni	0.88
Al	0.53
Cu	0.43
Cr	0.31
Mn	0.12
C (from CO_2)	0.07
Ti	0.06
Na	0.06
H (from H_2O)	0.05
Co	0.035
K	0.02

For the certification of UM-1, twenty-five laboratories provided analytical results for nickel, copper, and cobalt.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Ni	0.88 ± 0.01
Cu	0.43 ± 0.01
Co	0.035 ± 0.01

A copy of Mines Branch Technical Bulletin TB 177 "Nickel-copper-cobalt ores SU-1 and UM-1: Their characterization and preparation for use as standard reference materials" will be provided with each order of UM-1.

Niobium Ore OKA-1

OKA-1 is a sample of niobium ore typical of the carbonatite deposit at Oka in Western Quebec. The deposit has been characterized mineralogically in detail at CANMET.

Mineralogical composition

Mineral	wt %
Calcite	84
Apatite	5
Biotite	2
Feldspar	2
Magnetite	2
Dolomite	1
Siderite	1
Clays	1
Chlorite	1
Pyrochlore	<1

Twenty laboratories provided results for niobium by X-ray fluorescence, colorimetry, D.C. plasma-spectrometry, gravimetry, atomic emission and atomic absorption techniques.

Approximate chemical composition

Constituent	wt %
Ca	31.3
Fe	2.8
Si	2.4
Mg	1.3
Mn	1.1
Sr	1.0
P	1.1
Al	0.9
S	0.6
Nb	0.4
K	0.3
Na	0.2
Zn	0.05
Loss on Ignition	31.9

RECOMMENDED VALUE AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Nb	0.37 ± 0.01

A certificate of analysis will be issued with each order of OKA-1. A copy of CANMET Report 81-1E "OKA-1: A certified niobium reference ore" will be forwarded on request to the Coordinator, CCRMP.

Noble Metals-Bearing Sulphide Concentrate PTC-1

PTC-1, PTM-1 and PTA comprise a suite of certified reference materials containing the platinum-group metals. PTC-1 is a flotation concentrate of Sudbury ore, its principal constituents being Cu-5.2%; Ni-9.4%; S-23.5%; and Fe-26.9%.

Ten laboratories provided analyses for the certification of five selected elements.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	oz/ton	µg/g
Pt	0.087 ± 0.006	3.0 ± 0.2
Pd	0.37 ± 0.02	12.7 ± 0.7
Rh	0.018 ± 0.002	0.62 ± 0.07
Au	0.019 ± 0.003	0.65 ± 0.10
Ag	0.17 ± 0.01	5.8 ± 0.4

A copy of Mines Branch Technical Bulletin TB 176 "Noble-metals-bearing sulphide concentrate PTC-1: Its characterization and preparation for use as a standard reference material" will be provided with each order of PTC-1.

Noble Metals-Bearing Nickel-Copper Matte PTM-1

Matte PTM-1 was produced from Sudbury ore and was provided by Falconbridge Nickel Mines Limited. This material contains appreciable concentrations of most platinum-group metals. Approximate chemical analyses for the major constituents gave the following values: Ni-44.8%; Cu-30.2%; Fe-1.58%; S-21.6%.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	oz/ton	µg/g
Pt	0.17 ± 0.01	5.8 ± 0.4
Pd	0.24 ± 0.02	8.1 ± 0.7
Rh	0.026 ± 0.005	0.9 ± 0.2
Au	0.052 ± 0.005	1.8 ± 0.2
Ag	1.9 ± 0.2	66 ± 7

A copy of Mines Branch Technical Bulletin TB 182 "Noble-metals-bearing nickel-copper matte PTM-1: Its characterization and preparation for use as a standard reference material" will be provided with each order of PTM-1.

Platiniferous Black Sand PTA-1

PTA-1 was supplied by B.H. Levelton and Associates, Vancouver. It is from the Tulameen River area of British Columbia. Mineralogical examination of similar material revealed the presence of at least ten minerals known to contain platinum-group elements with an iron-bearing platinum alloy being predominant. Approximate chemical analyses for the major constituents of PTA-1 gave the following values: Fe-63.0%; SiO_2-3.6%; Al-2.9%; Ca-1.2%; and Mg-0.6%.

Nine laboratories provided platinum analyses for the certification of PTA-1.

RECOMMENDED VALUE AND 95% CONFIDENCE INTERVALS

Constituent	oz/ton	µg/g
Pt	0.089 ± 0.004	3.05 ± 0.14

A copy of Mines Branch Technical Bulletin TB 138 "Characterization and preparation of standard reference materials that contain noble metals: (A) PTA (Ores) and (B) PTM (Nickel-Copper-Matte)" will be provided with each order of PTA-1.

Non-Ferrous Dust PD-1

PD-1 is the result of a cooperative effort between CCRMP and the Air Pollution Technology Centre of Environment Canada to prepare a non-ferrous dust from a base metal smelter for use in a nationwide analytical quality assurance program operated by the Federal Provincial Committee on Air Pollution and also to provide a reference material for laboratories concerned with the analysis of similar environmental samples.

PD-1 is a composite of samples of dusts from Number 1 and 2 Baghouses and a smaller sample of electrostatic precipitator dusts collected from the zinc and copper roaster stacks of Hudson Bay Mining and Smelting Company Limited in Flin Flon, Manitoba. The material is essentially zincite containing varying minor to trace amounts of chalcocite, chalcopyrite, covellite, ferrites, galena, iron oxides, quartz, pyrite, pyrrhotite, sphalerite, elemental sulphur and complex sulphates, silicates and arsenates.

Approximate chemical composition

Constituent	wt %
Zn	35.9
Fe	12.20
S (Total)	8.23
S (Sulphate)	4.27
Cu	7.03
Si	3.05
Pb	2.75
As	0.76
Cd	0.28
Hg	389 µg/g
H_2O (105°C)	0.40

Twenty six laboratories provided analytical results for one or more of lead, arsenic and mercury.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Pb	2.75 ± 0.02
As	0.77 ± 0.02
Hg	389 ± 18 µg/g

A certificate of analysis will be issued with each order of PD-1. A copy of CANMET Report 81-7E "PD-1: A certified non-ferrous reference dust" will be forwarded free of charge on request to the Coordinator, CCRMP.

Tungsten Ores CT-1, BH-1, and TLG-1

CT-1 is a sample of a scheelite ore obtained in 1973 from Canada Tungsten Corporation, Tungsten, N.W.T. In decreasing order of abundance, the minerals present are: pyroxene, quartz, pyrrhotite, amphibole, calcite, mica, dolomite, feldspar, scheelite, chalcopyrite, and clay minerals.

BH-1 is a sample of wolframite ore, handpicked in 1973 from a stockpile at the Burnt Hill deposit neat Fredericton, New Brunswick, the deposit being owned by International Paper Company Limited. Minerals present in decreasing order of abundance are: quartz, biotite, chlorite, muscovite, feldspar, pyrrhotite, beryl and topaz, wolframite, cassiterite and rutile, pyrite, molybdenite, bismuth, bismuthinite and galena, and chalcopyrite.

TLG-1 is a sample of a low-grade scheelite ore from Browne's Lake mine, Beaverhead County, Montana, and was donated by General Electric Company, Cleveland, Ohio. In decreasing order of abundance, minerals present are: quartz, calcite, hydrogarnet, amphibole, dolomite, chlorite, feldspar, mica, clay minerals, scheelite, hematite, magnetite, sphalerite and chalcopyrite.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	W
	wt %
CT-1	1.04 ± 0.02
BH-1	0.422 ± 0.008
TLG-1	0.083 ± 0.004

A certificate of analysis will be issued with each order of CT-1, BH-1 or TLG-1. A copy of CANMET Report 76-5 "Tungsten ores CT-1, BH-1 and TLG-1: Their characterization and preparation for use as certified reference materials" will be forwarded free of charge on request to the Coordinator, CCRMP.

Uranium-Thorium Ore DL-1a

DL-1a is intended as a replacement for reference ore DL-1 the supply of which is exhausted. DL-1 had been part of a popular suite of seven uranium-thorium ores, the others being DH-1, BL-1, BL-2, BL-3 and BL-4. DL-1a is waste-rock typical of the property of Denison Mines Limited in Elliot Lake, Ontario. It is a pale yellow arkose sandstone containing uraninite and brannerite and possibly traces of monazite and uranothorite.

Twenty laboratories and fourteen laboratories provided results for uranium and thorium, respectively. Preliminary data for iron, sulphur and lead are also reported. Evidence for the state of secular equilibrium of DL-1a is presented.

Approximate chemical composition

Constituent	wt (%)
SiO_2	85.5
Al	5.3
Fe	0.9
S	0.4
Ca	0.3
K	0.2
Mg	0.2
Na	0.09
Ti	0.09
LOI (900°C)	1.4
H_2O (105°C)	0.2

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
U	0.0116 ± 0.0003
Th	0.0076 ± 0.0004

A certificate of analysis will be issued with each order of DL-1a. A copy of CANMET Report 80-10 "DL-1a: A certified uranium-thorium reference ore" will be forwarded free of charge on request to the Coordinator, CCRMP.

Uranium-Thorium Ore DH-1a

DH-1a is intended as a replacement for reference ore DH-1 the supply of which is exhausted. DH-1 had been part of a popular suite of seven uranium-thorium ores, the others being DL-1, BL-1, BL-2, BL-3 and BL-4. DH-1a is ore-grade material typical of the property of Denison Mines Limited in Elliot Lake, Ontario. It is a sercitic, feldspathic quartzite containing about 10% pyrite on a whole-ore basis. The radioactive minerals are principally uraninite and brannerite but traces of monazite and uranothorite are also present.

Approximate chemical composition

Constituent	wt %
SiO_2	79.75
Fe	5.17
S	4.82
Al	3.44
K	1.43
Mg	0.07
Ca	0.04
Na	0.04
C (total)	0.05
H_2O (105° C)	0.07

The recommended value for uranium is the mean of 45 results by the volumetric-umpire method performed at CANMET.

Twelve laboratories provided analytical results for thorium. Methods included colorimetry, X-ray fluorescence, neutron activation analysis and radiometry.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
U	0.2629 ± 0.0003
Th	0.091 ± 0.003

A certificate of analysis will be issued with each order of DH-1a. A copy of CANMET Report 80-11E "DH-1a: A certified uranium-thorium reference ore" will be forwarded free of charge on request to the Coordinator, CCRMP.

Uranium Ores BL-1, BL-2, BL-3, and BL-4

These four reference materials remain from a suite of six ores, from the two principal uranium-producing regions of Canada, which were prepared to replace the previous reference materials of the Canadian Uranium Producers' Analytical Sub-committee. The stocks of the other two, DH-1 and DL-1, both from the Elliot Lake region of Ontario, have been exhausted and now replaced by DH-1a and DL-1a.

The four materials, BL-1, BL-2, BL-3 and BL-4, from the Beaverlodge area of northwestern Saskatchewan, are relatively free of thorium, are in secular equilibrium, and cover a range of concentrations that should make them useful as reference materials for radiometric methods of analysis.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	Th	U
	wt %	
BL-1	15 ± 1	0.022 ± 0.001
BL-2		0.453 ± 0.005
BL-3		1.02 ± 0.01
BL-4		0.173 ± 0.004

A copy of CANMET Report 77-64 "Radioactive ores DH-1, DL-1, BL-1, BL-2, BL-3 and BL-4: Certified reference materials" will be provided with each order of one or more of the samples.

Uranium Ores BL-2a and BL-4a

BL-2a and BL-4a are intended as replacements for reference ores BL-2 and BL-4 the supplies of which are rapidly being depleted. BL-2a and BL-4a are samples of ore that is typical of the property of Eldorado Nuclear Limited in Beaverlodge, Saskatchewan, and consists of pitchblende in reddish-brown mylonitized oligoclase saturated with dusty hematite.

Approximate chemical composition

Constituent	BL-2a	BL-4a
	wt %	
SiO_2	59.12	61.22
Al	6.62	6.75
Fe	4.75	5.26
Ca	4.06	3.27
Na	3.42	3.24
Mg	1.50	1.38
S	0.36	0.28
K	0.33	0.36
U	0.43	0.13
Pb	0.090	0.031
H_2O (105°)	0.19	0.16
L.O.I.	5.16	4.44

The recommended value for uranium is the mean of single determinations for each of 25 bottles of each reference material performed at CANMET by the volumetric-umpire method.

RECOMMENDED VALUE AND STANDARD DEVIATION

Constituent	U
	wt %
BL-2a	0.426 ± 0.002
BL-4a	0.1248 ± 0.0007

A certificate of analysis will be issued with each order of BL-2a or BL-4a. A copy of CANMET Report 82-6E "BL-2a and BL-4a: Certified uranium reference ores" will be forwarded free of charge on request to the Coordinator, CCRMP.

Uranium Ore BL-5

The raw material for BL-5 was donated to CCRMP in September 1976, by the Resource Geophysics and Geochemistry Division of the Geological Survey of Canada at Ottawa, Ontario. This material is essentially a low-grade concentrate from Beaverlodge, Saskatchewan.

Mineralogical composition

Minerals in order of abundance
Plagioclase feldspar
Quartz
Uraninite
Calcite + dolomite
Hematite
Chlorite + muscovite
Galena
Carbon
Pyrite
Magnetite
Anatase + rutile
Chalcopyrite
Bornite
Pyrrhotite
Apatite

Approximate chemical composition

Constituent	wt %
Si	22.0
U	7.09
Al	6.0
Fe	5.9
Ca	4.0
Na	3.6
C	1.9
Pb	1.5
Mg	1.5
K	0.4
Ti	0.4
S	0.3
V	0.1
P	0.07
Mn	0.05
Zr	0.04
Sr	0.03
Cr	0.01
Th	0.004

Twenty-seven laboratories provided uranium results by one or more of seven methods.

RECOMMENDED VALUE AND 95% CONFIDENCE INTERVALS

Constituent	wt %
U	7.09 ± 0.03

A certificate of analysis will be issued with each order of BL-5. A copy of CANMET Report 79-4 "Uranium ore BL-5 - Certified reference material" will be forwarded free of charge on request to the Coordinator, CCRMP.

Zinc Concentrate CZN-1

CZN-1 was prepared from a sample of a flotation concentrate from the Sullivan mine of Cominco Ltd., at Kimberley, British Columbia. It is mineralogically complex and with a relatively large number of minor and trace elements at analytically useful levels of concentration.

Mineralogical composition

Mineral	wt %
Sphalerite (~10% Fe)	84
Galena	8.5
Pyrrhotite	4
Pyrite	1
Iron oxides	1
Quartz	0.5
Aluminosilicates	0.5
Carbonates	0.5

Thirty laboratories provided analytical results for one or more of the constituents. Preliminary data for eight other elements are also available.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Zn	44.74 ± 0.11
S	30.2 ± 0.2
Fe	10.93 ± 0.06
Pb	7.45 ± 0.05
Al_2O_3	0.25 ± 0.01
Mn	0.219 ± 0.07
Cu	0.144 ± 0.003
Cd	0.132 ± 0.002
Sb	0.052 ± 0.003
As	0.026 ± 0.002
Ag	93 ± 3 µg/g
Hg	43 ± 4 µg/g

A certificate of analysis will be issued with each order of CZN-1. A copy of CANMET Report 79-14 "Zinc concentrate CZN-1 - A certified reference material" will be forwarded on request to the Coordinator, CCRMP.

Zinc-Lead-Tin-Silver Ore KC-1

KC-1 was prepared from material hand-picked at the Kidd Creek deposit of Ecstall Mining Company Limited, Timmins, Ontario. KC-1 serves to complement the certified base metal ore MP-1 which contains lower zinc, lead and silver values but higher copper and tin values.

Mineralogical composition

Mineral	wt %
Sphalerite	32.7
Pyrite	29.9
Quartz	20.6
Galena	8.1
Feldspar	5.0
Cassiterite	0.9
Chlorite	0.9
Siderite	0.4
Pyrrhotite	0.3
Chalcopyrite	0.3
Carbon	0.2
Silver	0.1
Tetrahedrite + stephanite	0.05

Approximate chemical composition

Constituent	wt %
S	28
Zn	20.07
Fe	16
O	14
Si	11
Pb	6.87
Al	0.8
Sn	0.67
Ca	0.3
Na	0.2
C	0.2
Cu	0.112
Ag	0.112
K	0.1
Mn	0.05
Mg	0.05
H_2O (980°C)	0.7

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Zn	20.07 ± 0.07
Pb	6.87 ± 0.04
Sn	0.67 ± 0.01
Cu	0.112 ± 0.002
Ag	0.112 ± 0.002

A certificate of analysis will be issued with each order for KC-1. A copy of Technical Bulletin TB 193 "Zinc-lead-tin-silver ore KC-1: Its preparation and characterization for use as a certified reference material" and CANMET Report 78-2 "Revision of recommended values for reference ores MP-1 and KC-1" will be forwarded on request to the coordinator, CCRMP.

Zinc-Tin-Copper-Lead Ore MP-1a

MP-1a is intended to replace reference ore MP-1 the supply of which is rapidly being depleted. The raw materials for MP-1a were obtained from the deposit of Billitone Exploration Company Limited at Mount Pleasant in southwestern New Brunswick. MP-1a consists of materials from two sulphide veins blended with a small amount of mineralized rock.

Mineralogical composition

Mineral	wt %
Quartz	36.7
Sphalerite	31.1
Chorite	9.1
Galena	4.8
Chalcopyrite	4.1
Topaz	4.1
Arsenopyrite	3.8
Fluorite	2
Cassiterite	1.4
Kaolinite	1
Pyrite	0.7
Stannite	0.5
Rutile	0.5

Approximate chemical composition

Constituent	wt %
SiO_2	41.8
Zn	19.02
S	12.7
Fe	6.2
Pb	4.33
Cu	1.44
Ca	1.5
Sn	1.28
F	1.2
As	0.84
W	0.040
In	0.033
Bi	0.031
Mo	0.029
C (total)	0.03
Mg	0.02
Ag	69.7 µg/g
H_2O (105°C)	<0.01

Twenty laboratories participated in the interlaboratory program to provide analytical results for 10 elements in MP-1a. However, only a provisional value can be presented for tungsten at 0.040%.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

Constituent	wt %
Zn	19.02 ± 0.10
Pb	4.33 ± 0.03
Cu	1.44 ± 0.01
Sn	1.28 ± 0.04
As	0.84 ± 0.02
In	0.033 ± 0.001
Bi	0.032 ± 0.002
Mo	0.029 ± 0.001
Ag	69.7 ± 2.2 µg/g

A certificate of analysis will be issued with each order for MP-1a. A copy of CANMET Report 82-12E "MP-1a - A Certified Reference Ore" will be forwarded on request to the Coordinator, CCRMP.

ROCKS

Syenites SY-2 and SY-3 and Gabbro MRG-1

SY-2 is a syenite from the Bancroft area of eastern Ontario. SY-3 is a batch of syenite from the same source as SY-2 that was ground autogeneously with lumps of a concentrate containing uraninite, allanite and betafite to increase the concentration of uranium, thorium and rare earths.

SY-2 and SY-3 were prepared several years ago, but samples distributed internationally were analyzed on a casual basis only, to provide provisional values for a number of constituents. Only recently however were they analyzed in a systematic round-robin program to certify them as compositional reference materials.

MRG-1 is an augite-olivine gabbro from Mount Royal at Montreal, Quebec, intruded into sedimentary rocks of the lower Paleozoic. MRG-1 is compositionally different from other certified reference rock samples and the recommended values should be of interest to rock analysts.

RECOMMENDED VALUES - COMPLETE ANALYSIS

Constituent	SY-2	SY-3	MRT-1
		wt %	
SiO_2	60.10	59.68	39.32
Al_2O_3	12.12	11.80	8.50
Fe_2O_3	2.28	2.44	8.26
FeO	3.62	3.58	8.63
MgO	2.70	2.67	13.49
CaO	7.98	8.26	14.77
Na_2O	4.34	4.15	0.71
K_2O	4.48	4.20	0.18
H_2O^+	0.43	0.42	0.98
CO_2	0.46	0.38	1.00
TiO_2	0.14	0.15	3.69
P_2O_5	0.43	0.54	0.06
F	0.51	0.66	0.025
S	0.011	0.05	0.06
MnO	0.32	0.32	0.17

A copy of CANMET Report 79-35 "SY-2, SY-3 and MRG-1: Three rock samples as reference materials" will be forwarded with each order for SY-2, SY-3 or MRG-1.

SOILS

Soil Samples SO-1 to SO-4

Information on the samples follows.

SO-1: The sampling site was 23 km northwest of Hull, Quebec at 45°30'N, 75°58'40"W. The sample is somewhat weathered Champlain Sea clay from 35 to 75 cm below the surface in an upland position. In pedological terms, the sample is of the C horizon of Rideau clay, a Regosolic soil. It contains about 80% clay (<2 μm) of mixed mineralogy.

SO-2: The sampling site was in Montmorency Forest about 47°20'N, 71°9'W, 72 km north of Quebec City. Sampling depth was 10 to 30 cm. The sample, supplied by C.R. DeKimpe, is of the B horizon of a Ferro-Humic Podzol developed in sandy till. The organic matter content is approximately 10%.

SO-3: The sampling site was near Guelph, Ontario at 43°33'N, 80°19'W. The sample, supplied by R. Protz, is of the calcareous till parent material of the Guelph series, a Gray Brown Luvisol. The sample has an appreciable content of both calcite and dolomite.

SO-4: The sampling site was northeast of Saskatoon, Saskatchewan at 53°2'N, 106°42'W. The sample, supplied by H.B. Stonehouse, is of the A horizon of a Black Chernozemic soil developed in silty glacial lacustrine deposits.

Thirty-six laboratories provided analytical results for one or more elements. Preliminary data (given in CANMET Report 79-3) for 47 other elements is also available.

RECOMMENDED VALUES AND 95% CONFIDENCE INTERVALS

	SO-1	SO-2	SO-3	SO-4
		wt %		
Al	9.38 ± 0.17	8.07 ± 0.18	3.05 ± 0.11	5.46 ± 0.15
Ca	1.80 ± 0.07	1.96 ± 0.10	-	1.11 ± 0.06
Fe	6.00 ± 0.13	5.56 ± 0.16	1.51 ± 0.06	2.37 ± 0.07
K	2.68 ± 0.08	2.45 ± 0.04	1.61 ± 0.05	1.73 ± 0.03
Mg	2.31 ± 0.10	0.54 ± 0.03	-	0.56 ± 0.04
Mn	0.089 ± 0.003	0.072 ± 0.002	0.052 ± 0.002	0.060 ± 0.002
Na	-	-	0.74 ± 0.04	-
P	0.062 ± 0.01	-	-	0.090 ± 0.07
Si	25.72 ± 0.22	24.99 ± 0.23	15.86 ± 0.19	-
Ti	0.53 ± 0.02	0.86 ± 0.02	-	0.34 ± 0.02
		(µg/g)		
Cr	160 ± 15	16 ± 2	26 ± 3	61 ± 6
Cu	61 ± 3	7 ± 1	17 ± 1	22 ± 1
Hg	0.022 ± 0.003	0.082 ± 0.009	0.017 ± 0.007	-
Ni	94 ± 7	-	16 ± 3	26 ± 3
Pb	21 ± 4	21 ± 4	14 ± 3	16 ± 3
Sr	-	340 ± 50	217 ± 29	170 ± 18
V	139 ± 8	64 ± 10	-	90 ± 11
Zn	146 ± 5	124 ± 5	52 ± 3	94 ± 3

Each order for SO-1 to SO-4 will be issued a certificate of analysis. A copy of CANMET Report 79-3 "Soil samples SO-1, SO-2, SO-3 and SO-4 - Certified reference materials" will be forwarded on request to the Coordinator, CCRMP.

METALS AND ALLOYS

Commercial Purity Copper Rods, SSC-1, SSC-2, and SSC-3

The copper rods were intended as reference materials for spectrographic purposes. They were prepared and tested for homogeneity in the Mines Branch, between 1964 and 1966; the starting materials were donated by Canadian Copper Refiners Limited, Montreal, Quebec, and Metals and Alloys Limited, Leaside, Ontario.

To dope the copper matrix, impurities in granulated form were mixed with high-purity anode swarf, the mixture was cold-pressed into pellets 25.4 mm (1 in.) in diameter, and then the pellets were added to molten high-purity copper in appropriate quantities. The alloys are in the form of hot-rolled rods, 300 mm x 8 mm (12 in. x 5/6 in.).

For certifying the copper rods, ten laboratories provided analytical results for one or more elements. The results are based on a minimum of four and a maximum of eleven laboratories. The minimum number of determinations per element was seven, and the maximum fifty-one. The coefficient of variation ranged from 5.4% to 60.7%, with an overall mean of 25% at the 10 µg/g (ppm) level.

RECOMMENDED VALUES AND STANDARD DEVIATIONS

	SSC-1	SSC-2	SSC-3
	µg/g		
Ag	18.8 ± 5.81	13.9 ± 3.38	16.1 ± 3.59
As	1.16 ± 0.483	1.18 ± 0.612	5.45 ± 1.93
Bi	1.15 ± 0.325	0.097 ± 0.044	0.59 ± 0.012
Cd	N.F. -	10.0 ± 1.05	N.F. -
Fe	39.2 ± 7.18	31.9 ± 7.05	40.0 ± 8.82
Ni	17.6 ± 3.36	3.17 ± 1.04	48.0 ± 7.68
O	216 ± 68.3	176 ± 59.3	176 ± 46.7
Pb	65.3 ± 7.02	6.12 ± 1.20	4.58 ± 1.51
S	19.6 ± 6.79	28.9 ± 8.53	16.7 ± 8.93
Sb	2.64 ± 0.543	5.80 ± 0.662	1.63 ± 0.989
Se	7.28 ± 1.61	2.58 ± 0.821	3.87 ± 0.744
Sn	54.9 ± 6.70	10.0 ± 1.93	12.0 ± 1.68
Te	4.57 ± 0.775	1.24 ± 0.514	2.53 ± 0.629
Zn	33.3 ± 7.91	16.3 ± 5.15	15.3 ± 3.60

N.F. - Not found.

A copy of report MRP/MSL 75-149(TR) "Commercial purity copper rod SSC-1, SSC-2, SSC-3, SSC-4: Their generation and certification as certified reference materials will be provided with each order of one or more of these alloys.

Phosphor Bronze Discs 293, 304 , and 477

These 60-mm x 7-mm phosphor bronze discs, weighing 160 g each, are intended as reference alloys for spectrographic purposes; they were cast and tested for homogeneity in the Mines Branch in 1962.

For each phosphor bronze, a composite of chips from 10 randomly selected discs was prepared and a 100-g sample of this material was sent to each of five participating laboratories for analysis.

RECOMMENDED VALUES

Constituent	293	304	477
		wt %	
Cu	94.89	86.48	91.24
Sn	4.96	9.67	7.15
Fe	0.026	0.035	0.071
Pb	0.01	0.46	0.053
Zn	0.037	2.99	0.75
P	0.030	0.007	0.43
Al	-	0.05	-

A copy of report MRP/MSL 74-148(TR) "Phosphor bronze discs, No. 293, 304 and 477: Their preparation and certification as certified reference materials" will be included with each order of one or more of these materials.

MATERIALS WITH PROVISIONAL VALUES FOR SELECTED ELEMENTS

Sulphide-Bearing Ultramafic Rocks UM-1, UM-2, and UM-4

UM-1 is a sulphide-bearing ultramafic rock from the Giant Mascot mine at Hope, British Columbia. UM-2 and UM-4 are from the Werner Lake - Gordon Lake district of northwestern Ontario. These rock samples are intended as reference materials for the determination of ascorbic acid/hydrogen peroxide-soluble copper, nickel, and cobalt in ultramafic rocks to evaluate their ore potential.

Details of the mineralogy of UM-1, UM-2, and UM-4 are given in Geological Survey of Canada Paper 71-35 "Three geochemical standards of sulphide-bearing ultramafic rock: UM.1, UM.2 and UM.4". The following table by E.M. Cameron provides values for the major and minor elements; they are intended for information purposes only.

Approximate chemical composition

Constituent	UM-1	UM-2	UM-4
		wt %	
SiO_2	37.6	39.2	39.35
MgO	36.05	25.45	22.5
Fe (total) as FeO	17.2	12.95	12.8
S	3.53	0.94	0.44
CaO	2.34	4.68	6.27
Al_2O_3	1.00	7.23	8.98
Cr_2O_3	0.45	1.51	2.59
CO_2	0.26	0.10	0.26
MnO	0.16	0.08	0.15
TiO_2	0.10	0.24	0.35
Na_2O	0.08	0.32	0.45
K_2O	0.03	0.11	0.18
ZnO	0.012	0.004	0.008
P_2O_5	-	0.02	0.02
H_2O	0.42	6.27	4.86

GSC VALUES FOR COPPER, NICKEL, AND COBALT BY ASCORBIC ACID/HYDROGEN PEROXIDE METHOD (wt %)

Sample	Cu	Ni	Co
UM-1	0.41	0.83	0.029
UM-2	0.095	0.29	0.012
UM-4	0.054	0.19	0.007

INDEX OF CERTIFIED CONSTITUENTS

The recommended values of certified constituents in reference rocks SY-2, SY-3 and MRG-1 and in reference soils SO-1, SO-2, SO-3 and SO-4 are reported in the description of these materials.

Aluminum -

0.13 %; CCU-1
0.13 %; CZN-1
0.15 %; CPB-1
0.17 %; MW-1
0.509 %; SCH-1
5.10 %; SL-1

Antimony -

0.052 %; CZN-1
0.36 %; CPB-1
3.57 %; CD-1

Arsenic -

0.026 %; CZN-1
0.056 %; CPB-1
0.66 %; CD-1
0.77 %; PD-1
0.83 %; MP-1a

Bismuth -

0.023 %; CPB-1
0.032 %; MP-1a
0.111 %; PR-1

Cadmium -

0.0143 %; CPB-1
0.132 %; CZN-1

Calcium -

0.029 %; SCH-1
0.040 %; MW-1
26.79 %; SL-1

Cobalt -

0.035 %; UM-1
0.041 %; SU-1a

Copper -

0.112 %; KC-1
0.144 %; CZN-1
0.254 %; CPB-1
0.43 %; UM-1
0.522 %; HV-1
0.967 %; SU-1a
1.44 %; MP-1a
24.71 %; CCU-1

Gold -

0.65 µg/g; PTC-1
1.8 µg/g; PTM-1
1.86 µg/g; MA-2
7.5 µg/g; CCU-1
17.8 µg/g; MA-1

Indium -

0.033 %; MP-1a

Iron (Total) -

0.72 %; SL-1
1.244 %; PR-1
8.43 %; CPB-1
10.93 %; CZN-1
60.73 %; SCH-1
66.08 %; MW-1

Iron (ferrous) -

1.36 %; MW-1

Lead -

0.106 %; CCU-1
2.75 %; PD-1
4.32 %; MP-1a
6.87 %; KC-1
7.45 %; CZN-1
64.74 %; CPB-1

Magnesium -

0.020 %; SCH-1
0.021 %; MW-1
7.40 %; SL-1

Manganese -

0.219 %; CZN-1
0.777 %; SCH-1

Silver -

4.3 µg/g; SU-1a
5.8 µg/g; PTC-1
66 µg/g; PTM-1
69.1 µg/g; MP-1a
93 µg/g; CZN-1
139 µg/g; CCU-1
626 µg/g; CPB-1
0.112 %; KC-1

Mercury -

5.5 µg/g; CPB-1
43 µg/g; CZN-1
61 µg/g; CCU-1
389 µg/g; PD-1

Molybdenum -

0.029 %; MP-1a
0.058 %; HV-1
0.594 %; PR-1

Nickel -

0.88 %; UM-1
1.233 %; SU-1a

Niobium -

0.37 %; OKA-1

Phosphorus -

0.011 %; MW-1
0.054 %; SCH-1

Potassium -

0.011 %; MW-1
0.026 %; SCH-1

Rhodium -

0.62 µg/g; PTC-1
0.9 µg/g; PTM-1

Silicon -

0.35 %; CPB-1
1.22 %; CCU-1
2.15 %; MW-1
3.78 %; SCH-1
16.70 %; SL-1

Sodium -

0.019 %; SCH-1

Sulphur -

0.007 %; SCH-1
0.793 %; PR-1
1.26 %; SL-1
17.8 %; CPB-1
30.2 %; CZN-1

Thorium -

15 µg/g; BL-1
76 µg/g; DL-1a
0.091 %; DH-1a

Tin -

0.67 %; KC-1
1.28 %; MP-1a

Titanium -

0.031 %; SCH-1

Tungsten -

0.083 %; TLG-1
0.42 %; BH-1
1.04 %; CT-1

Uranium -

0.0116 %; DL-1a
0.022 %; BL-1
0.1248 %; BL-4a
0.173 %; BL-4
0.2629 %; DH-1a
0.426 %; BL-2a
0.453 %; BL-2
1.02 %; BL-3
7.09 %; BL-5

Zinc -

3.22 %; CCU-1
4.42 %; CPB-1
19.01 %; MP-1a
20.07 %; KC-1
44.74 %; CZN-1